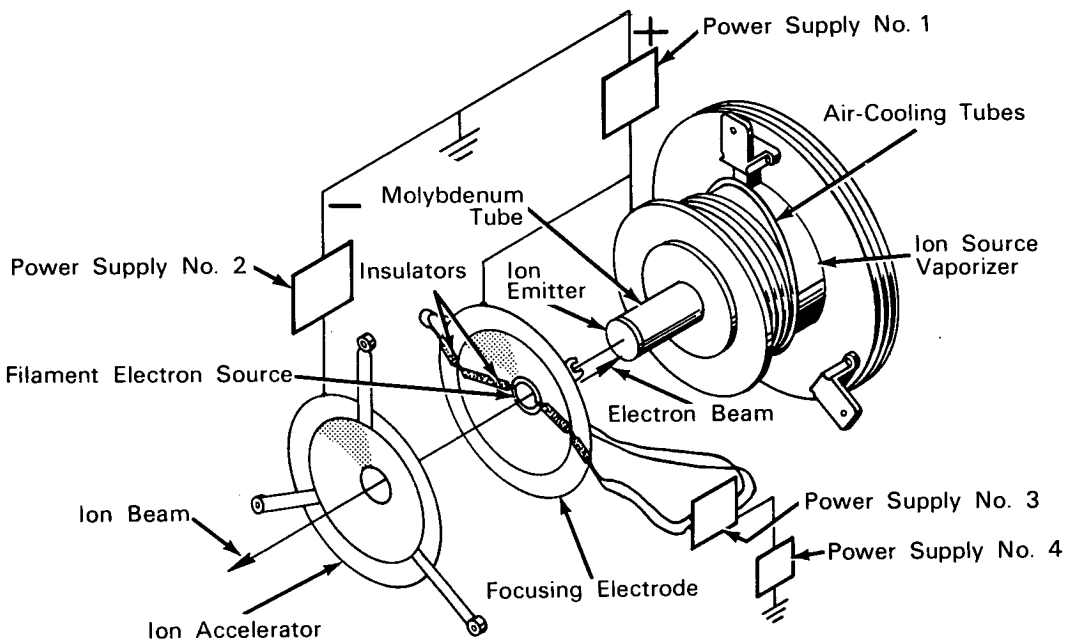
June 1964

Brief 63-10440

NASA TECH BRIEF

New Apparatus Increases Ion Beam Power Density



EXPLODED VIEW

The problem: To increase the amount of power obtainable from ion rockets or engines. Such engines employ a system that generates ions and electrostatically accelerates them to very high exhaust velocities. With the electrostatic ion accelerators of various designs that have been under development, a saturation (space-charge limited) condition occurs which prevents further increase in the number of ions that can be accelerated and therefore limits the power obtainable from the ion source.

The solution: A system incorporating an ion source and emitter, an ion-beam focusing electrode with an electron emission source, and an ion accelerator. It is believed that the fast-moving electrons from the electron source strike the ion emitter surface and decrease the space charge surrounding the ion emitter. As a result of this decrease in the opposing electrostatic field, the number of ions accelerated per unit area (ion beam density), and therefore the engine power, increases.

How it's done: The major units comprising the ion beam system are shown in the exploded view, above. The vaporizer for heating an ionizable source, such as cesium, is surrounded by air-cooling tubes to control the amount of cesium vapor that flows through the molybdenum tube to the ion emitter disc of porous

(continued overleaf)

tungsten, 0.048-inch-thick. The emitter disc and tube which constitute the ion emitter assembly, are heated by a wire radiation heater (not shown), which encircles the tube. The beam-forming or focusing electrode is provided to control the initial focusing of the ion beam. This electrode has a central aperture that is coaxial with the emitter assembly. A circular filament which serves as an electron source is mounted concentrically in the aperture of the focusing electrode. The ion accelerator has a conical configuration similar to that of the focusing electrode and is electrically insulated from the emitter/focusing electrode system.

Power supply No. 1 supplies a positive potential (with respect to ground) in the range of 0 to 20 kilovolts to the vaporizer, the ion emitter assembly, and the focusing electrode. Power supply No. 2 supplies a negative potential (with respect to ground) in the range from 0 to 10 kilovolts to the ion accelerator. These supplies establish a potential gradient for acceleration of the positive cesium ions from the ion emitter to the ion accelerator. The circular-filament electron source receives heating current from power supply No. 3. Power supply No. 4 pumps electrons from ground into the filament supply.

In operation of the system, elementary cesium is placed in the vaporizer, which is maintained below 300°F, and the ion emitter is heated to approximately 2,000°F. Under these conditions, cesium vapor is formed and flows through the ion emitter, where the vapor is ionized by the hot tungsten surface. The positive cesium ions are accelerated through the aperture in the focusing electrode toward the accelerator. The electrons from the filament in the focusing electrode move at high velocity toward the ion emitter and neutralize part of the space charge surrounding it. As a result of this action, the density of the cesium ion beam is increased above that obtainable without the electron source. The potential of the electron emitter is set at approximately the space charge voltage that exists at the emitter location; this potential is usually within a few hundred volts of the ion emitter voltage.

Notes:

1. Although the illustration shows the focusing electrode as being spaced from the ion source, it is actually mounted immediately adjacent to the ion emitter.
2. The fast-moving electrons will not travel in the direction of the ions because the accelerator operates at a high negative potential.
3. The heat transfer from the molybdenum tube to the vaporizer is sufficient to vaporize the cesium.
4. Both the focusing and accelerating electrodes are spin-formed from nickel sheet.
5. For further information about this innovation inquiries may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B63-10440

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Source: Lionel V. Baldwin and Virgil A. Sandborn
(Lewis-73)